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Sugary beverage and food consumption, and leukocyte telomere length maintenance in pregnant women

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Abstract

Leukocyte telomere length (LTL) has been inversely associated with sugar-sweetened beverage (SSB) consumption in cross-sectional studies, but no studies have examined whether dietary intake influences LTL over time. This study examined longitudinal associations between sugary foods and beverages and LTL. Participants were 65 overweight and obese pregnant women, aged 18-45, from a mindfulness intervention study conducted from early pregnancy (≤16 weeks gestation) and followed through 9 months postpartum. During pregnancy and postpartum, dietary intake was measured with 24-hour diet recalls and LTL was assessed using quantitative polymerase chain reaction. Adjusting for sociodemographic and health characteristics, decreased SSB consumption from baseline to 9 months postpartum was associated with greater concurrent LTL lengthening (β= −0.102, 95% CI −0.192, −0.013). No associations between sugary foods and LTL were found in either period. The finding that reduced SSB consumption is associated with increased LTL warrants investigation in large cohort studies.

Added sugar consumption, particularly from sugar-sweetened beverages (SSBs), has been associated with diet-sensitive disease.[1, 2] The mechanisms of these associations are not fully understood. Telomeres are the DNA-protein caps at the end of the chromosomes that protect the genomic DNA from damage. Telomeric shortening may represent a mechanism by which greater sugar intake accelerates cardiometabolic disease.[3] To date, two cross-sectional studies have found associations between SSB consumption and shorter telomere length.[4, 5] However, prospective studies are needed to investigate whether dietary behaviors relate to telomeric changes over time. To address this, we examined the intakes of foods and

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beverages with added sugar and their longitudinal relations with leukocyte telomere length (LTL), in a pilot study of pregnant women.

METHODS

Overweight and obese women <16 weeks pregnant participated in an intervention comparing effects of an 8-week mindfulness program on psychosocial well-being and gestational weight gain, with follow up until 9 months postpartum.[6] The intervention was registered at clinicaltrials.gov as NCT01307683. The analytic sample was comprised of 65 women with complete dietary and telomere length data out of 104 women in the intervention group. Dietary and biological measures were not collected from control participants. Informed consent was obtained from all study participants. Study procedures were approved by the University of California, San Francisco, Committee on Human Research and the California Pacific Medical Center Institutional Review Board.

Measures

At baseline, 32-34 weeks gestation, and 9 months postpartum, two 24-hour diet recalls were administered by trained interviewers on one weekday and one weekend day. At each time point, we estimated energy-adjusted mean servings of common sources of added sugars: dairy desserts, sweetened yogurt, baked goods, candy, syrups and sauces, and SSBs. Diet quality was assessed using the Alternate Healthy Eating Index-2010.

LTL was measured at baseline, 3 months postpartum, and 9 months postpartum. Total genomic DNA was purified using QIAamp® DNA blood Mini kit (QIAGEN, Cat#51106) from whole blood stored at −80 °C and quantified by measuring OD260. The LTL assay was performed using the quantitative polymerase chain reaction method to measure telomere length relative to standard reference DNA (T/S ratio).[7] The average inter-assay coefficient of variation was 2.5%.

Statistical Analysis

LTL measures were standardized at each time point and changes in z-scores were estimated. Bivariate associations between individual-level characteristics and baseline LTL z-score were estimated using simple linear regression and ANOVA. Next, changes in dietary intake and LTL across multiple time points were examined using mixed linear models for repeated measures. Lastly, multivariable linear regression models were used to examine the relation between changes in servings of foods and beverages with added sugars and changes in LTL z-score. Models for change at 32-34 weeks gestation included age, race/ethnicity, high school diploma, prepregnancy obesity, baseline smoking and physical activity, and concurrent change in AHEI-2010 scores. Models for change at 9 months postpartum included age, race/ethnicity, high school diploma, prepregnancy obesity, and concurrent changes in smoking, physical activity, and AHEI-2010 scores.

Statistical analyses were conducted using SAS software 9.3 (SAS Institute, Cary, NC). Statistical tests were two-sided and significance was considered at $P<0.05$.

RESULTS

At baseline, the mean age was 28.4 ± 0.7 years (**Table 1**). The majority of participants were African American or Hispanic, had some college education or higher, and were physically inactive. The mean change in LTL z-score from baseline to 3 months postpartum was 0.006 (5^{th} to 95^{th} percentile: −0.673 to 0.719) and from baseline to 9 months postpartum was 0.019 (5^{th} 95^{th} percentile: −0.654 to 0.597). Overall LTL change was not significant (*P>0.10*).

At baseline, a marginal association was observed between LTL and consumption of SSBs (β= −0.155, 95% CI −0.353, 0.042) (data not shown). At follow-up, significant associations were found between: (1) decreased consumption of SSBs from baseline to 32-34 weeks gestation and LTL lengthening from baseline to 3 months postpartum (β=−0.082, 95% CI −0.162, −0.002), and (2) decreased consumption of SSBs from baseline to 9 months postpartum and concurrent LTL lengthening (β=−102, 95% CI −0.192, −0.013) (**Table 2**). Further investigation showed that associations were strongest among those who decreased SSB consumption by ≥2 servings (≥16 ounces) (data not shown). No associations were observed between consumption of sugary foods and changes in LTL z-score.

DISCUSSION

Excessive consumption of SSBs is a global health crisis.[8] The results of our pilot study suggest that reducing SSB consumption during the prenatal and postpartum periods is associated with extended telomere length, independent of other characteristics. Although consistent with prior cross-sectional studies in Korean[4] and US[5] adults, the repeated measures of diet and LTL in the current study provide a better understanding of how telomere length maintenance may be sensitive to the metabolic effects of added sugars over time. While the mechanisms underlying SSBs and telomere length have not been fully established, the primary mechanisms for chronic disease are well known. Unlike sugary foods that contain other nutrients, consumption of sugary beverages do not contribute to feelings of satiety, leading to an overconsumption of calories and eventual weight gain.[9] Intake of SSBs also results in a rapid increase in blood glucose and insulin, which, over time, can adversely affect insulin sensitivity, oxidative stress, and systemic inflammation, processes known to influence telomeric shortening and increase the risk of diet-sensitive chronic disease.[10]

Our study has several limitations including its sample size, which precluded us from adjusting for all health behaviors known to influence LTL. However, the variables in the final models are known to influence both dietary intake and LTL from prior studies. In addition, the study involved pregnant women in the context of a mindfulness intervention, which may limit generalizability but likely not lead to bias as all participants were in the intervention group. Further adjustment for number of classes attended did not change the results. Offsetting these limitations is the fact that the findings are consistent with earlier cross-sectional results in different populations. Although the first time periods for diet and LTL did not overlap precisely, the second time periods were identical and both time spans showed significant associations between SSB consumption and telomere length. This suggests this association can be detected within short time spans. The vast literature of the

metabolic consequences of SSBs lend further credence to the potential influence of SSBs on telomere length maintenance.

To our knowledge, this is the first study to show longitudinal associations between changes in SSB consumption and extended LTL. While larger observational and experimental studies are needed to confirm this relationship, limiting consumption of SSBs is consistent with the available evidence.

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Table 1

Sociodemographic and health characteristics of 65 study participants and baseline LTL z-score

	n (%) or mean (SE)	LTL z-score, mean (SE)	*P*
Age at enrollment, in years	28.4 (0.7)	−0.02 (0.13)	*0.007*
Race/ethnicity			*0.38*
White or Other	20 (30.8)	−0.14 (0.24)	
African American	23 (35.4)	−0.15 (0.15)	
Hispanic	22 (33.9)	0.23 (0.25)	
Educational attainment			*0.64*
High school diploma or less	22 (33.9)	−0.10 (0.17)	
Some college or higher	43 (66.2)	0.03 (0.17)	
Prepregnancy BMI			*0.13*
<30 kg/m2	36 (55.4)	0.15 (0.20)	
≥30 kg/m2	29 (44.6)	−0.23 (0.13)	
Smoking			*0.98*
Current or former smoker[a]	26 (41.9)	−0.02 (0.17)	
Never smoker	36 (58.1)	−0.03 (0.19)	
Leisure-time physical activity[b]			*0.40*
Inactive or light activity	37 (56.9)	−0.10 (0.19)	
Moderate or vigorously active 3 times/week	10 (15.4)	0.48 (0.26)	
Moderate or vigorously active 5 or more times/week	14 (21.5)	−0.16 (0.22)	

LTL, leukocyte telomere length

[a]Only one study participant was a current smoker at baseline; thus the current and former smoker groups were combined.

[b]Measured using the Stanford Brief Activity Survey

Table 2

Change in intakes of foods and beverages with added sugars in relation to change in LTL z-score

	Mean (SD) servings			Change in LTL z-score from baseline to 3 months postpartum[a]		Change in LTL z-score from baseline to 9 months postpartum[b]	
	Baseline	**32-34 weeks gestation**	**9 months postpartum**	**β** [c]	**95% CI**	**β** [d]	**95% CI**
Dairy desserts	0.34 (0.32)	0.23 (0.28)	0.12 (0.17)	0.101	−0.070, 0.273	0.109	−0.087, 0.306
Sweetened yogurt	0.04 (0.09)	0.13 (0.24)	0.00 (0.02)	0.054	−0.340, 0.448	−0.442	−1.334, 0.451
Baked goods	0.42 (0.68)	0.57 (0.30)	0.40 (0.24)	0.017	−0.030, 0.064	−0.021	−0.069, 0.027
Candy	0.20 (0.49)	0.07 (0.17)	0.16 (0.39)	−0.021	−0.245, 0.204	0.133	−0.147, 0.413
Syrups and sweet sauces	1.20 (0.12)	0.87 (0.56)	1.33 (0.13)	0.029	−0.032, 0.091	−0.017	−0.079, 0.045
Sugar-sweetened beverages	1.30 (1.01)	1.02 (0.60)	1.27 (0.95)	**−0.082**	**−0.162, −0.002**	**−0.102**	**−0.192, −0.013**

Boldface indicates statistical significance (p<0.05)

LTL, leukocyte telomere length

[a] Compared with changes in diet from baseline to 32-34 weeks gestation

[b] Compared with changes in diet from baseline to 9 months postpartum

[c] Adjusted for age, race/ethnicity, education, prepregnancy BMI, baseline smoking and physical activity, and concurrent change in Alternate Healthy Eating Index-2010 scores.

[d] Adjusted for age, race/ethnicity, education, prepregnancy BMI, and concurrent changes in smoking, physical activity, and Alternate Healthy Eating Index-2010 scores.